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## A Teacher's Roles and Calculator Tasks in Two Twelfth-grade Mathematics Courses

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## ABSTRACT

The purpose of this study was to investigate the meanings that a teacher associated with calculators as reflected in the teacher's use of calculators in two 12th-grade mathematics courses, and to link those meanings to the institutions and individuals that supported the development of those meanings. By describing the teacher's conceptions of his roles in terms of the social norm that the teacher should prepare students for post-secondary education, this study linked the different expectations of a university and a technical college to curriculum differentiation at the secondary level.

## INTRODUCTION

The use of calculators is expected to have an impact on the mathematics that is taught in schools and the methods that are used to teach mathematics (NCTM, 1989; Ernest, 1989; Romberg, 1992). Unfortunately, the use of calculators in mathematics classes has been limited (National Center for Educational Statistics, 1992).

Existing educational research (e.g. Porter, 1990) contains considerable survey data that indicate that the limited use of calculators by teachers is correlated with a lack of teacher training in using calculators, teachers' concern that calculators may harm student outcomes, and the limited availability of calculators and calculator-based curriculum materials. However, there are few studies that have (a) investigated the meanings that a teacher associates with calculators as reflected in the teacher's use of calculators and (b) linked those meanings to the individuals and institutions that supported the development of those meanings. Understanding the meanings that a teacher associates with his or her instructional practice can provide a framework that educational reformers could use as a basis for planning teacher education programs that are meaningful to the teacher (Nickson, 1992).

## CONCEPTUAL FRAMEWORK

Structural Symbolic Interactionism [SSI] was used as the conceptual framework to integrate key concepts and data gathering procedures used in this study. SSI like other versions of Symbolic Interactionism is predicated on the following three premises. One, individuals act toward things on the basis of the meaning that the things have for them. Such things include everything an individual may note--physical objects, institutions, situations, activities, and requests of others. Two, meanings arise out of social interaction. Three, meanings are modified during the social interactions of reflective individuals.(Stryker, 1981)

An individual may fail to note things which should be noted, misinterpret things, take into account the expectations of others not immediately present, or interpret things based on previous interactions and definitions of how to act developed in similar situations. Nevertheless, an individual's actions are constructed by the individual out of what the individual takes into account. (Blumer, 1969)

In SSI as in other versions of Symbolic Interactionism, individuals are thought of as applying names to situations, elements of situations, other people, and themselves in order to organize their behavior. SSI focuses on individuals' specialized conceptions of themselves that they construct during interactions in relatively stable social systems such as schools. These specialized conceptions are called *roles*. In relatively stable social systems, people can share compatible meanings of what is expected of individuals in recurring situations. Roles based on these expectations are important as they enter into an individual's process of interpretation. (Stryker, 1980; 1981)

In order to understand an individual's actions in a relatively stable social system, one needs to understand the individual's conceptions of his or her roles in the specific situation. An individual's role can be described in terms of: (a) the individual's goals regarding the function of the role, (b) the individual's conception of the situation in which the role is performed, and (c) the individual's conceptions of the expectations of others identified by the individual as significant. SSI emphasizes the negotiated aspect of an individual's roles--the active participation of an individual in the construction of his or her roles and the influence of social structures on an individual's conception and performance of those roles. (Stryker, 1980; 1981)

When negotiating roles, an individual has some freedom in selecting the other individuals in a situation whose expectations will be considered significant. When identifying which individuals in a situation to consider significant, an important goal is the identification of individuals and expectations that will result in the enhancement of one's own self-esteem. (Brinkerhoff & White, 1989).

To help understand, an individual's selection and performance of roles, Stryker (1980) developed the following propositions.

Proposition 1. The greater one's relationship to a set of persons depends on a particular role, the more likely it is that the role will be invoked.

Proposition 2. The greater one's relationship to a set of persons depends on a particular role and the more positive the evaluation of the role, the more likely it is that the role will be invoked.

Proposition 3. The greater one's relationship to a set of persons depends on a particular role relative to other possible roles, the more likely it is that the role will be invoked.

Proposition 4. In a given situation, the greater the agreement among the expectations of those to whom one is committed by virtue of a given role, the more likely it is that the role will be invoked.

Proposition 5. The greater the number of persons for whom one's relationship depends on a particular role, the more likely it is that the role will be invoked.

Proposition 6. The greater the importance a particular role is relative to other roles, the greater the probability of role performances consistent with the role expectations attached to the role.

Proposition 7. The greater the importance a particular role is relative to other roles, the greater the probability the person will perceive a given situation as an opportunity to perform in terms of the role.

Proposition 8. The greater the importance a particular role is relative to other roles, the greater the probability that a person will actively seek out opportunities to perform in terms of that role.

Proposition 9. The greater the importance a particular role is relative to other roles, the greater the quality of the role performance will impact self-esteem.

Proposition 10. The greater the importance a particular role is relative to other roles, the higher the probability that the role performance will reflect institutionalized values and norms.

Proposition 11. External events cutting existing commitments will increase the probability of adoption of novel roles.

Proposition 12. The more that perceived consequences of a projected role change are in the direction of reinforcing valued commitments, the less the resistance to change.

Proposition 13. When the expectations of individuals and institutions an individual identifies as important call for incompatible actions, an individual will compartmentalize his or her role obligations to the degree permitted by social structures.

To capture the meanings an individual associates with a role and make those meanings accessible to others, researchers who use SSI as a conceptual framework investigate disorienting dilemmas such as the availability of new technology when the meanings individuals give to themselves and their experiences are called into question and revealed in ways not normally demonstrated (e.g., when teachers have access to new calculators). The use of SSI as a conceptual framework to investigate an individual's selection and performance of roles is most productive when employed with methods that allow for the testing and revising of tentative findings throughout an investigation, such as participant observation--participating in the daily life of the person under investigation either openly in the role of researcher or in some existing role, adopting the perspective of the individual studied across a variety of situations, and repeatedly revising and testing conceptual categories that describe significant findings. (Denzin, 1992)

Techniques used to collect data in participant observation studies include the direct observation of an individual's actions, interviews which are typically open-ended, and the collection of artifacts. The collection of data should be theoretically focused from the start. However, once data are collected, theoretical flexibility is called for as new data are analyzed and modifications are required. (Woods, 1992)

An inductive approach to the analysis of data in a participant observation study based on a SSI conceptual framework is appropriate in times of change when relevant experience is slight and theory is only weakly developed--such as when new

technology becomes available (Stryker, 1980). Researchers who proceed with an inductive approach to participant observation:

- \* formulate a rough definition of the phenomena of interest;
- \* develop tentative explanations of the phenomena;
- \* study a case to determine if the tentative explanation explains the case;
- \* reformulate explanations if they do not explain the case, or explain why the case should be excluded from the analysis;
- \* examine negative cases; and
- \* continue the process until a general relationship is established. (Denzin, 1978)

Research that draws upon SSI to investigate a teacher's actions should be more than a thick description of observed behaviors. Before an investigation is complete, data must be collected which identify the situational aspects of an individual's actions, relate the individual's actions and meanings to each other, and link the individual's meanings to the social relationships upon which they were built. (Denzin, 1978)

During the early exploration phase of an investigation, an investigator sharpens the focus of the study, develops a clearer understanding of how one's problem should be posed, learns what the appropriate data are, and develops conceptual categories that reflect information obtained during the study. During this period of exploration, a researcher may shift lines of inquiry, move in directions that previously were not contemplated, and change what are recognized as relevant data. (Blumer, 1969)

During inspection, the secondary phase of an investigation, a SSI researcher sharpens the connotative reference of concepts, formulates propositions, and flexibly examines categorical items and the nature of the relationship between those items. The inspection that takes place during this phase of the investigation should not be preset, routinized, or begin with categories whose nature has been set in advance. (Blumer, 1969)

## THE STUDY

The purpose of this study was to investigate the meanings that a teacher associated with calculators as reflected in the teacher's use of calculators in two 12th-grade mathematics courses, and to link those meanings to the institutions and individuals that supported the development of those meanings. Conceptually, this study was conducted in two stages. During the fall semester of the 1991-92 school

year, the focus of the study was narrowed and conceptual categories that reflected information obtained during the first stage of the study were developed.

The second stage of the study took place during the spring semester of the 1992-93 academic year and the fall semester of the 1993-94 academic year. During the second stage of the study, the connotative reference of concepts were sharpened, the ability of conceptual categories to explain significant findings was tested, and the relationship between conceptual categories were examined. Conducting the study during three school years allowed for: the development of conceptual categories to describe Mr. Hill's conceptions of his roles and calculator tasks he assigned in Technical Mathematics and Precalculus based on data collected in a variety of situations, and the identification of changes over time in Mr. Hill's conceptions of his roles and calculator tasks he assigned.

### **Exploratory Questions**

This study was initially guided by two broad questions. One, how did Mr. Hill use calculators in Technical Mathematics and Precalculus. Two, why did Mr. Hill use calculators in each course. These questions were intended to guide but not limit this investigation. The initial use of such general questions was meant (a) to reflect the belief that a researcher can not foresee all of the ways in which a teacher may use calculators or the meanings that the teacher associates with those uses and (b) to accommodate for the development of conceptual categories to describe Mr. Hill's use of calculators and the meanings that he associated with those uses based on data gathered during the study.

### **Development of the Research Question**

During the exploratory stage of the study, Mr. Hill indicated that he did not see himself as doing any teaching in Technical Mathematics. He made the following comment, prior to my first observation of Technical Mathematics--a self-paced programmed learning course.

This is the class I don't teach. We use programmed learning books. Those are the books we use [indicating three different textbooks stacked above study carrels in the back of the room].

Since Mr. Hill did not believe he taught in Technical Mathematics, in a strict sense I could not investigate how Mr. Hill used calculators while teaching. However,

Mr. Hill did assign tasks in Technical Mathematics and Precalculus. The tasks that a teacher assigns are the projects, questions, problems, constructions, applications, or exercises a teacher assigns students (NCTM, 1991). In this study, calculator tasks were considered the result of Mr. Hill's actions--assigning students a task and allowing students access to calculators.

Based on data collected during the exploratory stage of the study, the following more specific research question was developed that (a) reflected observations of Mr. Hill's use of calculators and his descriptions of why he used calculators and (b) suggested important concepts and their relationships to be studied in further detail as the study progressed.

- How were differences in the calculator tasks assigned in Technical Mathematics and Precalculus related to Mr. Hill's conceptions of his roles in each course?

### **Data Collection**

Interviewing Mr. Hill, collecting artifacts, and observing Mr. Hill's classes were the primary methods used to collect data. Interviews with Mr. Hill were conducted to: (a) collect his descriptive accounts concerning how and why he used calculators in his classes and (b) confirm conceptual categories generated from data collected during the study to describe his conceptions of his roles and calculator tasks he assigned in Technical Mathematics and Precalculus.

During the first year of the study, Mr. Hill was interviewed on three occasions. The first interview focused on why Mr. Hill used calculators in his classes. The second interview focused on Mr. Hill's description of materials he used in his classes and factors he took into consideration when selecting these materials. In the third interview, Mr. Hill was asked to confirm conceptual categories that I had generated to describe factors that influenced his instructional practices. Prior to each interview Mr. Hill was informed of the general focus of the interview.

Arranging interviews with Mr. Hill during the third year of the study was difficult. During the third year of the study, Mr. Hill was busy supervising two student teachers and preparing for the enrollment of all ninth-graders in Algebra I. However, Mr. Hill's interactions with the student teachers and the mathematics curriculum committee allowed for the collection of additional data in situations where his interactions with others revealed perceptions not enacted during interviews or classroom observations. The additional data could be used to confirm or modify conceptual categories.

Mr. Hill was interviewed twice during the third year of the study. In the first interview, Mr. Hill was asked to confirm categories I had generated from data collected during the study to describe calculator tasks assigned in Technical Mathematics and Precalculus and factors that influenced his uses of calculators. In addition, he was asked to identify any categories not discussed previously. In the second interview, Mr. Hill was asked to confirm categories used to describe calculator tasks assigned in Technical Mathematics and Precalculus, identify any additional categories that had not been discussed previously, describe how he intended to use the TI-82 calculators he had just purchased, and describe factors that influenced his plans to use the new calculators. Prior to each interview, Mr. Hill was informed of the focus of the interview and given a copy of the categories I used to describe how and why calculators were used in his classes.

Artifacts were a second source of data. Artifacts collected during the study included calculator tasks assigned in Technical Mathematics and Precalculus and documents that reflected the expectations of individuals and institutions Mr. Hill identified as important. Artifacts that were collected included: nine Precalculus assignments, a Precalculus test on which the use of any calculators was forbidden on the first part of the test and the use of graphing calculators was required on the second part of the test, guidelines for the university mathematics placement test, a contract that Technical Mathematics students signed that identified what was expected of students, 187 pages of assignments from the programmed learning textbooks used in Technical Mathematics, materials from professional conferences Mr. Hill attended, six articles Mr. Hill wrote for the local newspaper reporting the participation of the high school math team in area contests, an article Mr. Hill wrote for the district newsletter describing technical education, three letters to the editor of the local newspaper concerning the school district, three articles from the local newspaper concerning the school district, minutes from the district's mathematics curriculum planning committee, and the school district's strategic plan, annual performance report, and annual budget.

Observation were a third source of data. During the exploratory stage of the study, classroom observations focused on how Mr. Hill used calculators in Technical Mathematics and Precalculus. During the second stage of the study, classroom observations focused more specifically on calculator tasks that Mr. Hill assigned in the two courses.

No formal observation format was used during either stage of the study. During observations, I sat in the back of the classroom, observing, listening, and making field notes. Field notes were written during observations or as soon as possible after leaving the school. Field notes consisted of observational, theoretical, and methodological notes. Observational notes consisted of written descriptions of calculator tasks, the school, classrooms, classroom activities, Mr. Hill, students, student teachers, and another teacher of Technical Mathematics. Theoretical notes consisted of my conceptual speculations. Methodological notes consisted of comments concerning the data-gathering process.

During the spring semester of the first year of the study, I conducted eight observations of Mr. Hill's Precalculus class, one observation of his Technical Mathematics class, and two observations of Mr. Hill at educational conferences. During the spring semester of the second year of the study, I observed Mr. Hill's Precalculus class four times, his Technical Mathematics class three times, and his Algebra II class once. During the first year of the study, I served as a substitute teacher in his Precalculus class on one occasion when he attended a meeting of the district mathematics curriculum planning committee.

During the first two years of the study, Mr. Hill taught Precalculus during the first period of the school day and was assigned a preparation period during the second period. This arrangement allowed time for informal conversations with Mr. Hill after observing Precalculus. These conversations focused on classroom activities that I had observed and factors that influenced Mr. Hill's instructional practice.

During the third year of the study, I was able to schedule 22 observations of Mr. Hill's Precalculus class. In order to maximize my exposure to a variety of calculator tasks, I observed the majority of two units, one on trigonometric functions and the other on converting between degrees and radians--units I had also copied from the Technical Mathematics programmed learning textbooks. In an informal conversation at the beginning of the third year of the study, Mr. Hill identified the former unit as one in which the use of graphing calculators was beneficial and the later unit as one in which the use of graphing calculators was not essential. In addition to these observations, I attended a presentation by the school district's strategic planning committee and the annual school district budget meeting with Mr. Hill. During the third year of the study, on three occasions, I served as a substitute teacher when he attended professional meetings or took students to a mathematics competition.

During the third year of the study, Mr. Hill did not teach Technical Mathematics. However, the analysis of the data collected during the second year of the study did not result in the identification of additional categories to describe the calculator tasks Mr. Hill assigned in Technical Mathematics or his conceptions of his roles in Technical Mathematics. In an informal conversation with Mr. Hill at the beginning of the third year of the study, Mr. Hill confirmed conceptual categories generated to describe calculator tasks assigned in Technical Mathematics and his conceptions of his roles in Technical Mathematics. After it became clear that further observations would not result in the generation of additional categories to describe the calculators tasks Mr. Hill assigned in Technical Mathematics or his conceptions of his roles in Technical Mathematics, I decided additional observations of his Technical Mathematics class would not result in additional conceptual categories.

During the third year of the study, Technical Mathematics was taught by Mr. Roth. To confirm the usefulness of the categories generated during the first two years of the study to describe calculator tasks assigned in Technical Mathematics and to collect copies of additional pages of calculator tasks assigned in Technical Mathematics, I observed Mr. Roth's Technical Mathematics class on 15 occasions. Like Mr. Hill, Mr. Roth used the set of programmed learning textbooks in Technical Mathematics, did not allow students to take the books home, expected students to have their own scientific calculators, and used graphing calculators in Algebra I but not in Technical Mathematics.

### **Data Analysis**

Data were analyzed throughout the study. After each observation and interview, I attempted to identify examples of instructional uses of calculators, Mr. Hill's descriptions of instructional uses of calculators, and his justifications for instructional uses of calculators. I then identified tentative conceptual categories to describe Mr. Hill's conceptions of instructional uses of calculators in Technical Mathematics and Precalculus and factors that influenced his use of calculators. After tentative categories were identified, I reread existing data to identify subcategories for each category. Additional interviews and conversations with Mr. Hill were then conducted to confirm the use of the categories and subcategories. This process continued until: (a) additional observations, conversations, and interviews did not result in the identification of additional categories or subcategories, and (b) Mr. Hill's instructional

uses of calculators were linked to the individuals and institutions that supported those actions.

### **Background Orientation-The School District, Mr. Hill, and His Classes**

In order to provide information about the context in which this study took place, the Harrisville School District, Mr. Hill, and his classes are described in the following sections.

#### **The School District**

The Harrisville School district is a consolidated district. The high school is located in the largest community in the district--a town of 3,800 residents. The high school is also attended by students from the surrounding rural area and two neighboring villages--each with less than 1,000 residents. During the three years that this study was conducted, graduating classes ranged from 73 to 83 students. Ninety-nine percent of the residents in the county in which the school was located were Caucasian. Eighty percent of the residents older than 25 had completed high school. The median family income in the county was \$31,000. Unemployment in the county was 5%. (Young, 1992)

During the first year of the study, Mr. Castle was hired as the district's first assistant superintendent of curriculum. One of his responsibilities was to serve as chairperson of the district's strategic planning committee. The strategic planning committee identified shared beliefs, developed a mission statement for the district based on these beliefs, and developed action plans based on the mission statement. The committee then presented their work to the school board, published it in the local newspaper, and shared it at four public meetings.

Shared beliefs identified by the committee included:

- \* A community's survival is dependent on it's ability to generate wealth.
- \* The ultimate definition of civilization is the self-sufficiency of its members.
- \* The most significant influence to a person's development is his/her family.
- \* Everyone has the right to question everything.
- \* All people have the right to learn what they want to learn when they want to learn it.
- \* Each person is responsible for his/her actions.

The following is the mission statement prepared by the committee.

The mission of the Harrisville School District, a catalyst for excellence in the state, is to ensure our children are self-sufficient by creating a child-centered environment that is inviting, inclusive, integrated, and individualized.

The assistant superintendent was serious about the district's strategic plans.

When I attended a presentation by the district's strategic planning committee, a parent asked, "What would happen if teachers didn't follow the recommendations of the committee?" The assistant superintendent responded, "They would be encouraged to look for work elsewhere." During the second year of the study, a mathematics teacher who had taught in the district for 17 years was put on probation for not meeting the expectations of the assistant superintendent. During the third year of the study, the local newspaper reported that the teacher's contract was not renewed.

During the third year of the study, citizens concerned about the increase in the number of administrators in the district and the increase in spending organized as a group, attended school board meetings, and encouraged citizens to attend the district's annual budget meeting. The annual budget meeting was attended by over 340 people, including me. The initial budget proposed by the school board was rejected. A reduced budget proposed by the group of concerned citizens was passed. However, the vote at the annual budget meeting was advisory but not binding. At the next school board meeting, the board passed a budget proposed by the superintendent that was greater than the budget rejected at the district's annual budget meeting.

Concern over the amount of influence the district administration had on the school board and district was expressed in letters to the editor in the local newspaper. A graduate of Harrisville High School wrote in the June 17, 1993 edition of the newspaper, "The superintendent says this is what has to be ... and no one ever questions it." A local businessman suggested in the June 24, 1993 edition of the newspaper, "The administrative staff should only be making suggestions." A group of citizens concerned about these matters wrote in the September 2, 1993 edition of the newspaper, "teachers are not being allowed to take an active part in curriculum development." In school board elections held later that year, incumbent school board members were defeated by candidates supported by the group of citizens concerned about district spending.

This section reported the addition of an assistant superintendent, development of a district strategic plan, non-renewal of a tenured teacher, and passing an annual budget without widespread public support. These actions reflected the influence of the district administration in the district.

The influence of the district administration was also evident in Mr. Hill's classroom. During the course of the study, there was an increase in the bureaucratic constraints on Mr. Hill's instructional practice evident in the form of the new assistant superintendent observing Mr. Hill's classes, changes in Mr. Hill's teaching assignment, the development of a strategic plan for the mathematics department, and the assistant superintendent recommending that all students in the same grade study the same mathematics.

#### Mr. Hill

Mr. Hill was an experienced and professionally active teacher. He had taught mathematics at Harrisville High School for 25 years; he was the mathematics department chairperson; he worked with student teachers; he assisted with the district's debate program; and he coached the district's mathematics team and golf team. In addition to these school duties, he was a member of the state council of mathematics teachers, a national network of teachers of technical preparation, and the technical preparation and mathematics advisory committees at the technical college. Moreover, he attended mathematics competitions with his students; he attended mathematics education, technical preparation, and technology conferences; and he led calculator workshops in the Harrisville School District, in neighboring districts, and at the state conference of mathematics teachers. He had an undergraduate major in mathematics from the state university, was certified to teach secondary mathematics, and had a masters degree in education administration. In addition to being a teacher in the district, he was the father of a son and a daughter who had graduated from Harrisville High School and a son who attended Harrisville High School during the study.

Through his participation in professional development activities sponsored by the university, technical college, and professional teacher organizations, Mr. Hill was in contact with individuals interested in improving mathematics education. Through his interactions with mathematics teachers in his district, student teachers, and mathematics teachers from neighboring school districts, Mr. Hill could be considered a

legitimizer--an individual who affirms the worth of the messages of others through his or her own actions and who spreads the messages to individuals with whom the initiators of the messages are not in contact (Bertrand, 1972).

A year after this study Mr. Hill resigned his position with the school district. Mr. Hill accepted a position working on a federally funded school to work project involving several school districts.

### Mr. Hill's Classroom

Mr. Hill's classroom was adjacent to his office. A doorway in the southeast corner of the classroom connected the classroom to the office. A blackboard ran across the remainder of the east wall of the classroom. Twenty-five student desks were arranged in five rows facing the east wall. In the northeast corner of the room was the doorway to the hall. A portable hutch with 4 columns of 35 shelves was placed along the south wall, next to the doorway to the hall. Technical Mathematics programmed learning assignments were kept on these shelves. Along the remainder of the south wall was another blackboard. In the northwest corner of the classroom was a doorway to a suite of special education rooms. Four study carrels were placed along the west wall of the classroom. Technical Mathematics students sat in these carrels when working on tests. Windows ran the length of the south wall of the classroom.

During the summer prior to the third year of the study, the shelves and study carrels were moved to Mr. Roth's classroom--the teacher assigned to teach Technical Mathematics during the third year of the study. In addition, the doorway that had led to the suite of special education rooms was replaced with a wall.

### Students

Students in Technical Mathematics and Precalculus were seniors. Slightly over half of the students enrolled in each class were females. During the first and third year of the study, one student was enrolled in both Technical Mathematics and Precalculus. The total enrollment in Technical Mathematics and Precalculus represented slightly less than half of the senior class. A few seniors were enrolled in Algebra II each year. However, each year approximately half of the seniors were not enrolled in any mathematics class. In an informal conversation during the first year of the study, Mr.

Hill indicated he recommended to juniors in his Algebra II classes that intended to enroll in a four year college to enroll in Precalculus their senior year. He recommended to students that intended to attend a technical college to enroll in Technical Mathematics.

### Available Calculators

Students in Technical Mathematics and Precalculus owned their own scientific calculators. In an informal conversation during the third year of the study, Mr. Hill indicated that students: had been expected to purchase a scientific calculator in ninth-grade; did not all own the same brand of calculator; and were responsible for knowing how to operate their particular brand of calculator. In Precalculus, students were expected to use the classroom set of TI-81 calculators. In the fifth interview, Mr. Hill indicated that these calculators were also used by students in Algebra I and Algebra II. However, these calculators were not used in Technical Mathematics, even by students who had used these calculators when they were enrolled in Algebra I and Algebra II.

### Technical Mathematics

Prior to the first year of the study, Mr. Hill made arrangements with the technical college for a pilot program that made it possible for students to earn technical college credit for successfully completing Technical Mathematics in high school. The contractual agreement between the school district and the area technical college was announced in the June 18, 1992 edition of the local newspaper. The expectations of the technical college, school district, Technical Mathematics teachers, and Technical Mathematics students for one another were written as a contract. The contract specified that: (a) the purpose of the course was "to prepare students for Technical School or give college bound students a review of Algebra and/or Trigonometry," (b) class expectations involved "acceptable class behavior, acceptable class attendance and promptness, and making acceptable progress," (c) at the top of the grading scale "A = 93 - 100," and (d) "Calculators should be used for all of the courses and must be provided by the student."

During the first year of the study, in an informal conversation after Precalculus, I asked Mr. Hill to explain how it came to be that Technical Mathematics students were able to earn technical college credit. Mr. Hill responded:

I'm on two committees at the technical college. I knew they gave credit for some accounting classes. My Technical Mathematics class was similar to their mathematics class so I thought students could get credit for my class too. It's good public relations for the technical college. The average age there is 28. Kids leave here and get a poor job and end up there at 28. Maybe if they knew more about the technical college and had some credits they would go there right after high school.

Technical Mathematics was a class intended for seniors who planned to attend a post-secondary institution. As stated earlier in this section, the purpose of the course was to prepare students for technical school or give college bound students a review of Algebra and/or Trigonometry. The reader should not confuse Technical Mathematics with two other mathematics courses offered at Harrisville High School that emphasized applied arithmetic--Applied Business Math or General Math.

### **Technical Mathematics Students**

Enrollment in Technical Mathematics ranged from 13 to 15 students per class per year. In an informal conversation during the first year of the study, Mr. Hill indicated that Technical Mathematics students' most recent mathematics class may have been Algebra II, Geometry, Algebra I, or Prealgebra. Students with diverse mathematical backgrounds were enrolled in the same course because there were fewer than 12 students with similar mathematical backgrounds interested in enrolling in a technical mathematics class, and if enrollment in a class at Harrisville High School was lower than 12 students the class would be canceled.

### **Technical Mathematics Textbooks**

Three different programmed learning textbooks were used in Technical Mathematics. *Introductory Algebra: Programmed* (McHale, Christenson, & Roberts, 1986) was used by students who had not completed Algebra I. *Technical Mathematics I* (McHale, 1988) was the textbook used by students who had completed Algebra I. *Technical Mathematics II* (McHale & Witzke, 1990) was the textbook used by students who had completed Algebra II. The textbooks are described in the authors' preface as:,

"designed to provide students with the mathematical skills needed for success in technical mathematics ." (p. iii)

### **Technical Mathematics Activities**

Classroom activities I observed in Technical Mathematics did not vary significantly from day to day. Students would enter the class at various intervals during the passing time between classes, get their textbook from a shelf in the room, and sit at their desks. Once class began, students tended to either: (a) work in their textbook; (b) ask if a test they had completed had been corrected; (c) ask to take a test; or (d) talk to students sitting next to them about other students, sports, work, cars, or other classes. During the class period, the activities students engaged in varied only slightly. Students continued to: (a) work in their textbook; (b) ask if a test they had completed had been corrected; (c) ask to take a test and sit in a study carrel while completing the test; or (d) talk to students sitting next to them.

### **Precalculus**

#### **Precalculus Students**

Enrollment in Precalculus ranged from 13 to 19 students per class per year. Precalculus students were seniors, had been in Mr. Hill's Algebra II class their junior year, and intended to enroll in a four year college. During the first year of the study, Mr. Hill asked his Precalculus class, "How many of you are planning on taking Calculus next year?" All of the students raised their hands.

#### **Precalculus Textbooks**

Several different textbooks and worksheets from educational conferences and journals were used in Precalculus. During the majority of the year, students studied trigonometry. The preface of the trigonometry textbook (Lial & Miller, 1988) states that the textbook was designed to, "prepare students either for calculus or further work in electronics and other technical fields," and would indicate, "when a calculator would be appropriate and how to use it."

*Precalculus Experiments with the TI-81 Graphing Calculator* (Gilligan, 1991) was a second text used in Precalculus. In the second interview, Mr. Hill stated that he liked the text because, "it was written by someone who understood when you teach five different preps you are too busy to come up with good examples."

### **Precalculus Activities**

Precalculus students would enter class at various intervals during the passing time between classes and go to their assigned seat. The class periods I observed often began with Mr. Hill answering students' questions about the previous day's assignment or having students write their solutions on the blackboard. After answering questions about the previous day's assignment, Mr. Hill presented new material to the whole class and gave an assignment for the following day, consisting of problems in the textbook that Mr. Hill had instructed previous Precalculus students to circle. Daily assignments were not graded. However, before starting a new assignment, students were often tested on skills practiced on previous assignments.

The pattern of correcting assignments, presenting new material, and making new assignments was broken by activities Mr. Hill referred to as group activities or discovery learning. Occasionally, students would be expected to work in small groups to review for chapter tests, complete extra credit assignments that required students to prove trigonometric identities from older textbooks that were meant to supplement the current text, or use graphing calculators to investigate properties of trigonometric functions. Unlike activities observed in Technical Mathematics that varied only slightly from day to day, classroom activities observed in Precalculus varied from day to day.

## **Results**

### **Calculator Tasks**

The calculator tasks assigned in Technical Mathematics and Precalculus differed in terms of: the purposes of using calculators, the types of calculators available, how often calculator tasks were assigned, the physical locations students were to work on tasks, the grouping of students during tasks, and the mathematical topics of tasks ( Table 1). These categories were generated from data collected during classroom observations, informal conversations with Mr. Hill immediately after these observations, and interviews with Mr. Hill. Moreover, the characterization of each category is meant to reflect Mr. Hill's conceptions of the calculator tasks he assigned in Technical Mathematics and Precalculus.

Students in the Technical Mathematics class were never expected to use graphing calculators, never restricted from using their scientific calculators, and always expected to work individually in school. Students in the Precalculus class were

expected to use graphing calculators when investigating the graphs of trigonometric functions, not allowed to use calculators when calculating exact values of trigonometric or radical expressions, and expected to work individually as well as in groups in and out of school.

### **Mr. Hill's Roles**

The following section explores differences in Mr. Hill's conceptions of his roles in Technical Mathematics and Precalculus, by identifying: (a) his goals in each course, (b) his interpretation of the expectations of significant parties, and (c) his conceptions of the situations in which he performed his roles (Table 2). Terms used to describe differences in Mr. Hill's conceptions of his roles were: (a) generated from data collected from classroom observations, informal conversations with Mr. Hill immediately after these observations, and interviews with Mr. Hill and (b) meant to reflect Mr. Hill's conceptions of his roles in Technical Mathematics and Precalculus.

### **Goals**

Mr. Hill's primary goal in Technical Mathematics was to prepare students for enrollment at the technical college. A second goal Mr. Hill identified was for students to learn how to study on their own. Mr. Hill's primary goal in Precalculus was to prepare students for Calculus.

### **The Expectations of Others**

An individual has some freedom in selecting the other individuals and institutions whose expectations he or she considers significant. An important goal when selecting which individuals and institutions to consider significant, is the identification of expectations that will result in the enhancement of one's own self-esteem--the evaluation of one's actions compared to the actions of others (Brinkerhoff & White, 1989). In interviews and informal conversations throughout the study, Mr. Hill identified the expectations of the technical college, parents, the university mathematics faculty, the university mathematics placement exam, students, professional teacher organizations, and mathematics competitions as important. The following sections summarize the expectations of these individuals and institutions, and describe the recognition that Mr. Hill received for meeting their expectations.

Table 1

DIFFERENCES IN THE CALCULATOR TASKS ASSIGNED IN  
TECHNICAL MATHEMATICS AND PRECALCULUS

	TASKS ASSIGNED IN TECHNICAL MATHEMATICS	TASKS ASSIGNED IN PRECALCULUS
PURPOSES OF USING CALCULATORS	Perform calculations Approximate trig values Learn to use a calculator	Perform calculations Approximate trig values Learn to use a calculator Draw a straight line Graph a function Check an answer Investigate concepts
TYPES OF OF CALCULATORS AVAILABLE	Student-owned scientific	Student-owned scientific School-owned graphics
HOW OFTEN CALCULATORS WERE AVAILABLE	Unrestricted access to scientific calculators	Restricted when calculating exact values of trig or radical expressions
LOCATIONS STUDENTS WORKED ON TASKS	School	School Home
GROUPING OF STUDENTS	Individual	Individual Small group Whole class
MATHEMATICAL TOPICS	Polynomials Trigonometry Radians Vectors Matrices Complex numbers Analytic geometry Polar coordinates Statistics Rational numbers Base two Hexidecimals	Polynomials Trigonometry Radians Vectors Matrices Complex numbers Analytic Geometry Polar coordinates Statistics Limits

**Table 2**  
**DIFFERENCES IN MR. HILL'S CONCEPTIONS OF HIS ROLES  
 IN TECHNICAL MATHEMATICS AND PRECALCULUS**

	MR. HILL'S ROLES IN TECHNICAL MATHEMATICS	MR. HILL'S ROLES IN PRECALCULUS
REFLECTED THE FOLLOWING GOALS	Prepare students for technical college Teach students how to study independently	Prepare students for Calculus
CONFORMED TO THE EXPECTATIONS OF	The Technical College Administrators Students Parents	The University Administrators Students Placement Tests Math Competitions Professional Organizations
ACCOMMODATED THE FOLLOWING CONCEPTIONS OF THE SITUATION	Students' post-secondary plans Students' math backgrounds Limited time to prepare Limited time in each class period	Students' post-secondary plans Students' math backgrounds Limited time to prepare

**Technical Mathematics.**

When asked to identify factors that influenced his instructional practice in Technical Mathematics, Mr. Hill identified the technical college curriculum guide as the most influential factor when planning instruction in Technical Mathematics. Mr. Hill was the teacher of the first high school mathematics class in the area in which students earned technical college credit and was asked by the technical college to speak at other high schools about the success of his Technical Mathematics class.

**Precalculus.**

When asked to identify factors that influenced his instructional practice in Technical Mathematics, Mr. Hill identified the university, district administrators, and students as important.

**University Faculty.** Mr. Hill described his job as preparing students for the university and described his curriculum as pretty much like the Precalculus curriculum at the university. Annually the university mathematics department reported to high school faculty the mathematics placement scores of freshmen from their high school. Mr. Hill said he was regularly informed that students from his classes were prepared for college mathematics.

As the use of calculators at the university changed, the calculator tasks Mr. Hill planned to assign in Precalculus also changed. When asked in the fifth interview to identify factors that influenced his purchase of a new calculators, Mr. Hill said, "The university is going to start using them next year."

**District Administration.** The importance of the expectations of district administrators to Mr. Hill's conceptions of his roles changed over the years, as different administrators were employed by the district. During the first year of this study, Mr. Hill felt instructional decisions were made by teachers, and not administrators. However, during the third year of the study, Mr. Hill's actions reflected the addition of Mr. Castle to the administration staff and Mr. Castle's influence on the curriculum. The assistant superintendent stated it was his job to oversee the development of the district curriculum and encourage teachers who did not agree with the district's plans to look for employment elsewhere.

**Students.** Mr. Hill took into account the expectations of students when making assignments in Precalculus. On one occasion a student's letter to the editor in the local paper identified Mr. Hill as one of the two quality teachers in the district. However, the expectations of students dealt more with the scheduling of assignments so that they did not conflict with other commitments than the content of assignments or the availability of calculators.

### **The Situation**

Mr. Hill's conceptions and performance of his roles were shaped by his conceptions of the situations in which he performed his roles. Categories used to describe Mr. Hill's conceptions of the situations in which he worked included students' post-secondary plans, students' mathematical backgrounds, and limited time.

**Students' Post-Secondary Plans.**

When discussing students, Mr. Hill focused, in part, on the students' post-secondary plans. Mr. Hill described students in Technical Mathematics as students who planned to attend the technical college or did not plan to take any more mathematics in college. He described Precalculus students as college-bound students who intended to take Calculus. Mr. Hill advised Algebra II students to enroll the following year in Technical Mathematics or Precalculus, based on their post-secondary plans.

**Student's Mathematical Background.**

Another important element in Mr. Hill's conception of the situation in which he worked concerned the most recent mathematics class that students had completed. Mr. Hill described students in Technical Mathematics as students whose last mathematics class was Algebra II, Geometry, Algebra I, or Prealgebra. Students in Technical Mathematics were assigned different textbooks based on the last mathematics class they had completed. Mr. Hill described Precalculus students as students that he had in Algebra II the previous year.

**Limited Time.**

Throughout the study, Mr. Hill referred to limited time in two senses. On the one hand, Mr. Hill demonstrated that he was concerned about the limited time in each class period. For example, while explaining to me why a laboratory approach to Technical Mathematics was not feasible, he indicated that the 47-minute class periods at Harrisville High school were not sufficient for the activities. On the other hand, Mr. Hill was also concerned about the limited time that was available to prepare for each class. In the first year of the study, while discussing a new supplementary textbook he had purchased for Precalculus, that included calculator activities and directions on how to operate graphing calculators, Mr. Hill described the text as, "written by someone who recognizes when you have five preps you don't have time to make up good examples."

**Assigned Calculator Tasks in Relation to Mr. Hill's Roles****Incompatible Expectations**

Mr. Hill indicated in interviews and conversations that he perceived the expectations of the university and the technical college to be incompatible. The technical college expected students to use scientific calculators to solve applied problems, give approximate rather than exact values for radical and trigonometric expressions, and study mathematical topics such as base two and hexidecimals. The university recommended students use graphing and scientific calculators, use exact values for trigonometric and radical expressions, and investigate properties of functions. Given the incompatible expectations of the university and the technical college, Mr. Hill recommended to the mathematics curriculum committee that the district offer a sequence of college preparatory courses and a sequence of technical preparation courses to meet the incompatible expectations in different courses as suggested by Stryker's Proposition 13--when the expectations of individuals and institutions an individual identifies as important call for incompatible actions, an individual will compartmentalize his or her role obligations to the degree permitted by social structures.

**Technical Mathematics**

Mr. Hill's primary goal in Technical Mathematics was to prepare students for technical college. To prepare students for technical college, Mr. Hill planned the curriculum of his Technical Mathematics class using the curriculum guide from the area technical college and made arrangements for students to earn technical college credit for their high school Technical Mathematics class.

The shared expectations of the area technical college, the school district, Technical Mathematics students, and Mr. Hill for one another were expressed in the form of contracts. Mr. Hill's performance of his role in Technical Mathematics reflected these shared expectations--the curriculum of Technical Mathematics had to match the technical college curriculum guidelines.

Given Mr. Hill's interpretation of the situation in which he taught Technical Mathematics, following the curriculum requirements of the technical college meant using programmed learning textbooks. The technical college required students to study Algebra I, Tech Math I, or Tech Math II dependent upon the most recent mathematics class they had completed. To address the different curriculum

requirements for the three groups of students, Mr. Hill had students work out of programmed learning textbooks that were written by technical college mathematics instructors.

Taken individually, Mr. Hill's educational goals, conceptions of the expectations of individuals and institutions he identified as important, and conceptions of the situations in which he taught were insufficient to understand the calculator tasks assigned in Technical Mathematics. However, when understood as a whole, the calculator tasks assigned in Technical Mathematics class reflected: (a) Mr. Hill's goal to prepare students for technical college (students earned technical college credit while in high school); (b) the shared expectations of the technical college, students, parents, and the district (meet the requirements of the contract with the technical college); and (c) his conceptions of the situation in which he worked (teach students with diverse mathematical backgrounds in the same 47 minute class).

### **Precalculus**

In Precalculus, Mr. Hill's goal was to prepare students for Calculus. Preparing students for Calculus meant meeting the expectations of the university, the university mathematics placement exam, and professional education organizations.

Mr. Hill stated that the expectations of the university, the university mathematics placement exam, and professional education organizations were not as consistent as the expectations of the technical college, the school district, and Technical Mathematics students. During the third year of the study, prior to an observation, Mr. Hill informed me that, "Today we are doing factoring. I know the NCTM says to factor less but they have to be able to factor to get anywhere."

The conflicting expectations of the university, the university mathematics placement exam, and professional education organizations resulted in calculator tasks that did not consistently reflect the expectations of any one individual or institution. The mathematics topics studied in Precalculus reflected the expectations of university faculty expressed at a curriculum workshop for Precalculus teachers. The emphasis in Precalculus on calculating exact values of trigonometric and radical expressions, proving trigonometric identities algebraically, and graphing functions by hand--times when student access to calculators was restricted--reflected the expectations of the university mathematics placement test and mathematics competitions. However, the use of calculators to investigate mathematical concepts, the grouping of students, and

the use of scientific and graphing calculators reflected the expectations of professional education organizations expressed at conferences Mr. Hill attended.

As suggested by Stryker's Proposition 13--when the expectations of individuals and institutions an individual identifies as important call for incompatible actions, an individual will compartmentalize his or her role obligations to the degree permitted by social structures--the differences in the expectations of the university, the university mathematics placement exam, and professional organizations, resulted in, on any given day, the calculator tasks in Precalculus could reflect the expectations of one but not all of the institutions. To meet the conflicting expectations, Mr. Hill compartmentalized his role obligations in Precalculus on a day-to-day basis. Before mathematics competitions and the university math placement exam, the calculator tasks in Precalculus reflected the expectations of the competitions or the exam. Before competitions and the exam, Mr. Hill would remind students that they would not be able to use graphing calculators at the competitions or on the exam, and that they would be expected to know trigonometric identities.

During the third year of the study, the expectations of the university became more similar to the expectations of professional education organizations. The university changed from restricting the use of graphing calculators in Precalculus classes at the university to recommending the use of TI-82 graphing calculators in Precalculus classes. As the expectations of the university became more similar to the expectations of professional education organizations, Mr. Hill's conceptions and performance of his roles as a Precalculus teacher reflected the shared expectations as suggested by Proposition Four--in a given situation, the greater the agreement among the expectations of individuals and institutions that an individual identifies as important, the more likely it is that the individual's role performance will reflect the shared expectations. During the third year of the study, Mr. Hill purchased a classroom set of TI-82 graphing calculators, learned how to use the calculators, and made plans to use them in his Precalculus class.

Preparing students for post-secondary education was the common theme that unified Mr. Hill's educational goals for each of his classes, the individuals and institutions whose expectations he identified as important, his conception of the situation in which he taught, and the calculator tasks he assigned. During the first three years that the study was conducted, Mr. Hill was able to compartmentalize his conceptions of his role obligations in such a way that he could meet the diverse

expectations of individuals and institutions that he identified as important. Throughout the study, Mr. Hill received recognition for his efforts to meet the expectations of individuals and institutions he identified as important. As suggested in Stryker's Proposition 2--the more positively an individual's role performance is evaluated by individuals and institutions that the individual identifies as important, the more likely it is that the individual will perform the role again in similar situations--the recognition Mr. Hill received for previous performance of his role as a teacher reinforced his commitment to his conceptions of his roles in his Technical Mathematics and Precalculus classes. Mr. Hill's commitment to his conceptions of his roles was evident in the third year of the study when the district curriculum coordinator articulated his expectation that all students in the same grade study the same mathematics. Mr. Hill resisted the district curriculum coordinator's expectations and continued to support the current policy at Harrisville High School of offering a series of university preparatory courses and a series of technical college preparatory courses--an arrangement in which Mr. Hill had been successful at meeting the expectations of individuals and institutions he had identified as important. During the third year of the study, Mr. Hill stated in informal conversations that he felt he would have to meet the expectations of the district curriculum coordinator to keep his job. However, the following year, rather than except the new role of teaching all students in the same grade the same mathematics, Mr. Hill resigned his teaching position to work on a federally funded school to work program that supported student enrollment at the local technical college. As suggested by Stryker's Proposition 8-- the greater the importance a particular role is relative to other roles, the greater the probability that a person will actively seek out opportunities to perform in terms of that role--Mr. Hill sought out an opportunity to continue preparing students for post-secondary education.

## DISCUSSION

In this study, Mr. Hill's conceptions of his roles in Technical Mathematics and Precalculus were described in terms of his goals for himself in each course, his conceptions of the expectations of individuals and institutions he identified as important, and his conceptions of the situations in which he performed his roles. Mr. Hill's primary goal in both classes was to prepare students for post-secondary education--enrollment in the technical college or the university. Mr. Hill identified the expectations of the technical college and the university as primary influences on his

instructional decisions. Mr. Hill interpreted the situations in which he performed his roles in terms of students' post-secondary plans, students' mathematical backgrounds, the limited time to prepare for courses, and the limited time in each class period.

Although it may appear Mr. Hill's conceptions of his roles in Technical Mathematics and Precalculus were similar, differences in the expectations of the technical college and the university and the diversity of the mathematical backgrounds of students enrolled in Technical Mathematics resulted in differences in the calculator tasks assigned in the two courses. The assigned uses of calculators in Mr. Hill's Technical Mathematics class reflected the shared expectations of the technical college, the school district, Technical Mathematics students, and their parents. These shared expectations dictated a common path--follow the technical college curriculum guidelines. This resulted in Technical Mathematics students not using graphing calculators and not studying functions that combined polynomial and trigonometric functions--functions studied in Precalculus.

The conflicting expectations of the university, the university mathematics placement exam, mathematical contests, and professional organizations resulted in calculator tasks assigned in Precalculus that did not reflect the expectations of any one individual or institution consistently throughout the study. At times, Precalculus students were expected to use graphing calculators to solve systems of equations graphically or to investigate attributes of trigonometric functions as recommended by professional teaching organizations. However, students' access to graphing calculators was restricted in Precalculus prior to mathematics contests that: did not allow the use of graphing calculators, required students to prove trigonometric identities algebraically, and expected students to provide exact values of trigonometric and radical expressions.

By describing Mr. Hill's conceptions of his roles in terms of the social norm that the teacher should be preparing students for post-secondary education, this study linked the different expectations of a university and a technical college to curriculum differentiation at the secondary level. In addition, this study has shown that access to calculators and the ability to use calculators are not sufficient conditions to ensure calculators will be used. Mr. Hill's access to graphing calculators and the knowledge necessary to use them did not result in the use of graphing calculators in his Technical Mathematics class.

In closing I would like to underscore the utility of role as a construct and SSI as a conceptual framework for investigating and understanding the contexts that are most salient to a teacher as he or she constructs instructional practice in particular settings. Further investigations of factors that influence teachers' instructional practices could benefit from using SSI as a conceptual framework to examine such naturally occurring instances of curriculum differentiation in terms of the broader context in which members of different reference groups acknowledge different expectations of teachers. Investigating these broader contexts can provide a richer understanding of why specific curriculum differentiation is adopted in response to the multiple expectations modern cultures have of schools (Oakes, Gamoran, & Page, 1992).

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